

is probably a seasonal effect, since depletion in the long-wave end of the spectrum is largely due to absorption by water vapor, and water vapor is much more abundant in the atmosphere during the warm than during the cold season of the year.

(3) Variations in the visible part of the spectrum, while small, indicate about the same increase in the percentage content of visible radiation in the solar spectrum with decrease in air mass as is indicated by table 3, p. 479, MONTHLY WEATHER REVIEW for October, 1924 "Illumination equivalents of a gram-calory/min./cm² of radiation, with the sun at different zenith distances." The increase there shown from zenith distance 75.7 ($m=4.0$) to zenith

distance 25° ($m=1.1$) is 9 percent, which is the same as is shown for Zugspitze, above.

While existing solar radiation measurements in the Tropics are inadequate to give a complete picture of its characteristics, the data here presented do not substantiate the claims frequently made as to its excessive intensity as compared with that in temperate zones. The annual total received on a horizontal surface at Habana, Cuba, for example, is about the same as that received at Lincoln, Nebr., and considerably less than that received at stations in the States of California and Idaho; while the maximum hourly amount received at Miami, Fla., is considerably less than that received at most stations in central latitudes of the United States.

ROUTINE DAILY PREPARATION AND USE OF ATMOSPHERIC CROSS SECTIONS

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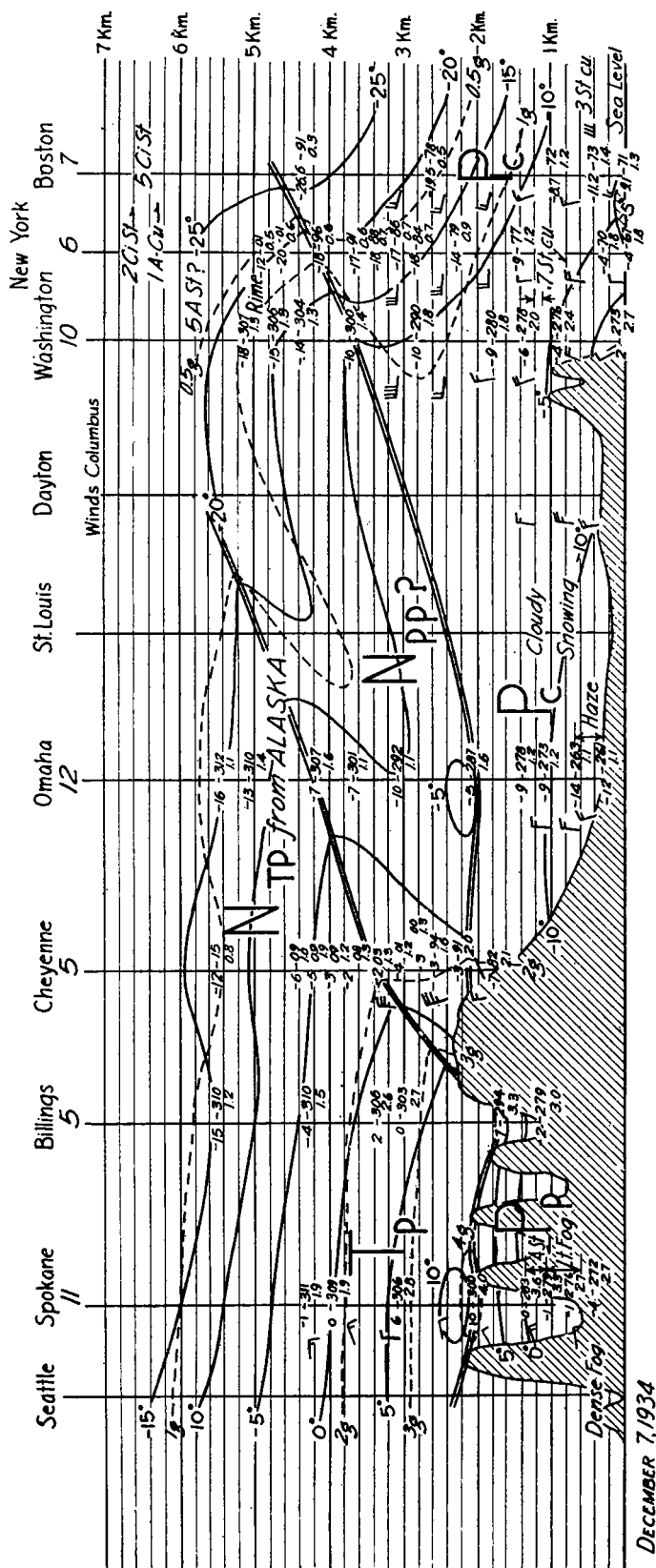
The greatly increased number of daily meteorological soundings through the lower troposphere by airplane which are now at the disposal of the American weather forecaster makes necessary the development of a system for the representation of these valuable data, in the most useful and comprehensive form which limited time will allow. Any complete three-dimensional representation of the fields of the meteorological elements is likely to remain too complicated a procedure for use in daily weather forecasting, and as yet our data from upper levels are far from sufficient for such a representation. However, some method of presenting a unified picture of atmospheric conditions in the vertical, corresponding to our two dimensional analysis of the surface data, is urgently needed, to supplement the present practice of representing the separate aerological soundings individually on one of the standard forms of diagrams. To obtain such a representation we have come to rely increasingly in our meteorological work at the Massachusetts Institute of Technology, on so-called "atmospheric cross sections." For such a cross section we choose a line, along which there lies a maximum number of airplane stations, as the base line, i. e., the line of intersection of the vertical plane with the ground surface. The data obtained from the airplane ascents are then plotted on the vertical cross-section sheet, the ordinates representing elevation, so that the frontal discontinuities may be drawn in. Subsequently isopleths of temperature, specific humidity, or any meteorological elements desired, may be sketched. Thus we get a two-dimensional picture, along a vertical plane containing a maximum number of observations, of the air mass and frontal structure of the atmosphere, and of the horizontal air movement. From the horizontal air movement, and the frontal slopes, we may draw conclusions about vertical velocities also.

During the past year I have worked up a large number of such atmospheric cross sections for short periods of special interest within the last 3 years, or when the data were more than usually complete. The results of this work proved to be of such interest and so illuminating that I decided at the end of last summer to try to work out some routine practice by which at least a part of the present extensive network of stations making daily airplane soundings might be utilized in the regular daily preparation of certain standard cross sections. For this purpose 3 groups of stations were chosen, 2 of these groups constituting rather straight north-south sections, and 1 long east-west section along a broken line. In the more

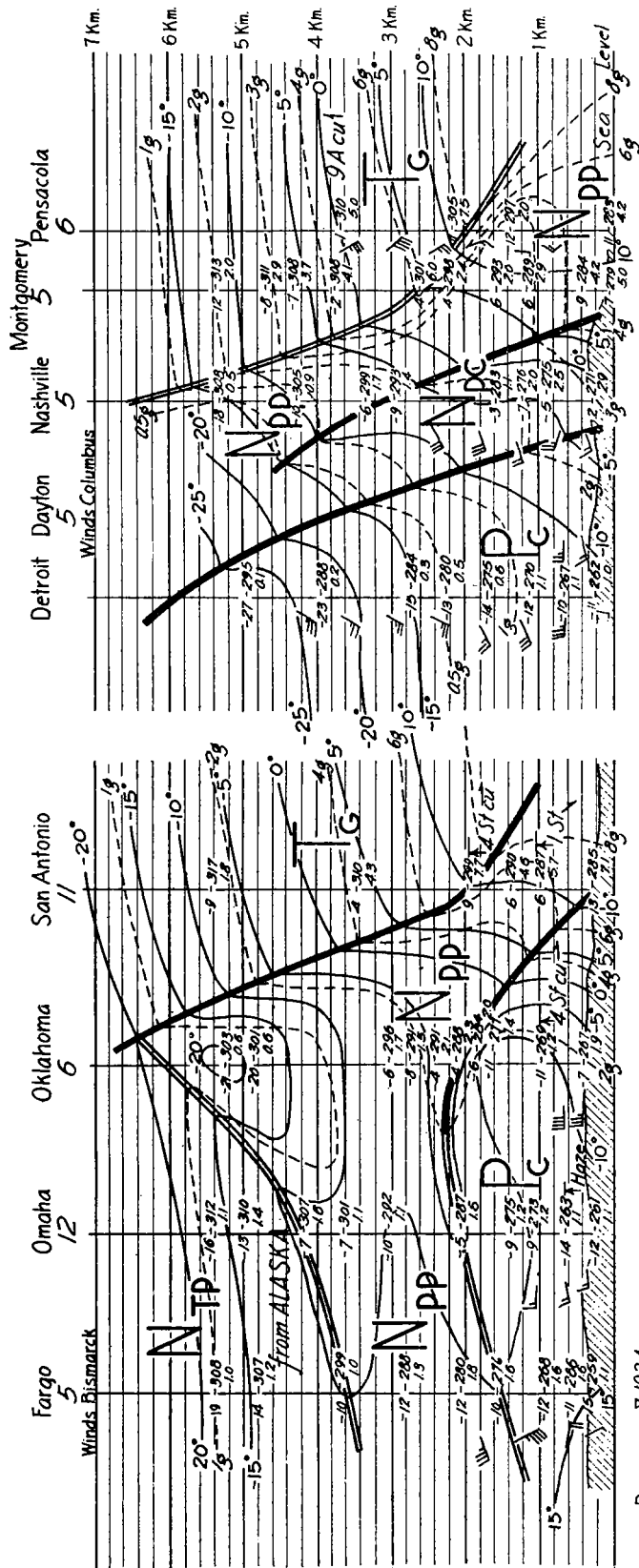
easterly north-south section are Detroit, Dayton, Nashville, Montgomery, and Pensacola; in the more westerly one, Fargo, Omaha, Oklahoma, and San Antonio. In the long broken east-west section we have Boston, New York, Washington, Dayton, St. Louis, Omaha, Cheyenne, Billings, Spokane, and Seattle. On our cross-section sheets the ordinates give elevations (scale 1 inch to 1 kilometer), and the abscissae are horizontal distances (same scale as the M. I. T. weather maps). The base line represents roughly the topographical contour, on the given scale of elevation, of the ground surface along each section. Vertical lines at the point of each station serve to facilitate the plotting of the data in the vertical.

Lack of time usually prevents the daily plotting of all three cross sections. Usually it is the aim to complete the east-west section every day, and the north-south sections only in cases of particular interest. There are occasions when, owing to more complete data or to the particular meteorological situation, the completion of one or both of the north-south sections may be preferred to that of the east-west section. The plotting procedure is quite simple. The desired stations are selected from the morning reports, and for each reported level the potential temperature and specific humidity are obtained graphically. Then at the respective elevations (points on the vertical line representing each station) the potential temperature and specific humidity are entered at the right, the actual temperature at the left. Where we have pilot-balloon observations, the wind direction and velocity (Beaufort) are also represented by barbed arrows, the direction parallel to the base line representing the direction of the baseline itself. Thus on a west-east section a wind arrow flying to the right and parallel to the base represents a west wind, on a north-south section, a north wind.

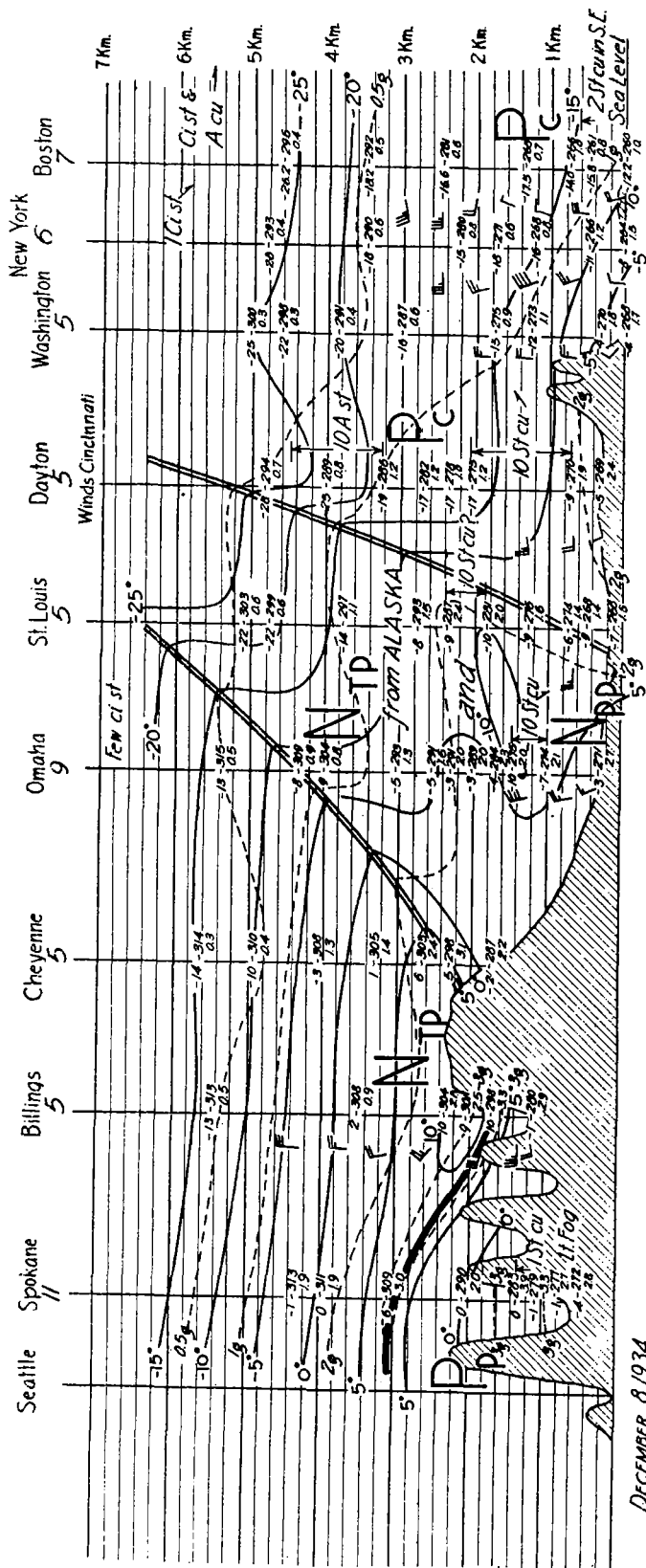
As soon as the data are entered, we are ready to carry out the analysis, or the location and designation of the fronts and air masses. This is not always easy to do, and requires considerable experience. It is best carried out in conjunction with the analysis of the surface map, but unfortunately the delay so frequently experienced in the receipt of some of the aerological data usually makes this impossible. Both the surface analysis and the cross-section analysis mutually benefit from such a joint consideration, but usually the surface analysis cannot be delayed until all the aerological observations are in, and of course the cross section analysis should be attempted only with the greatest possible amount of material plotted on the cross section. When the loca-



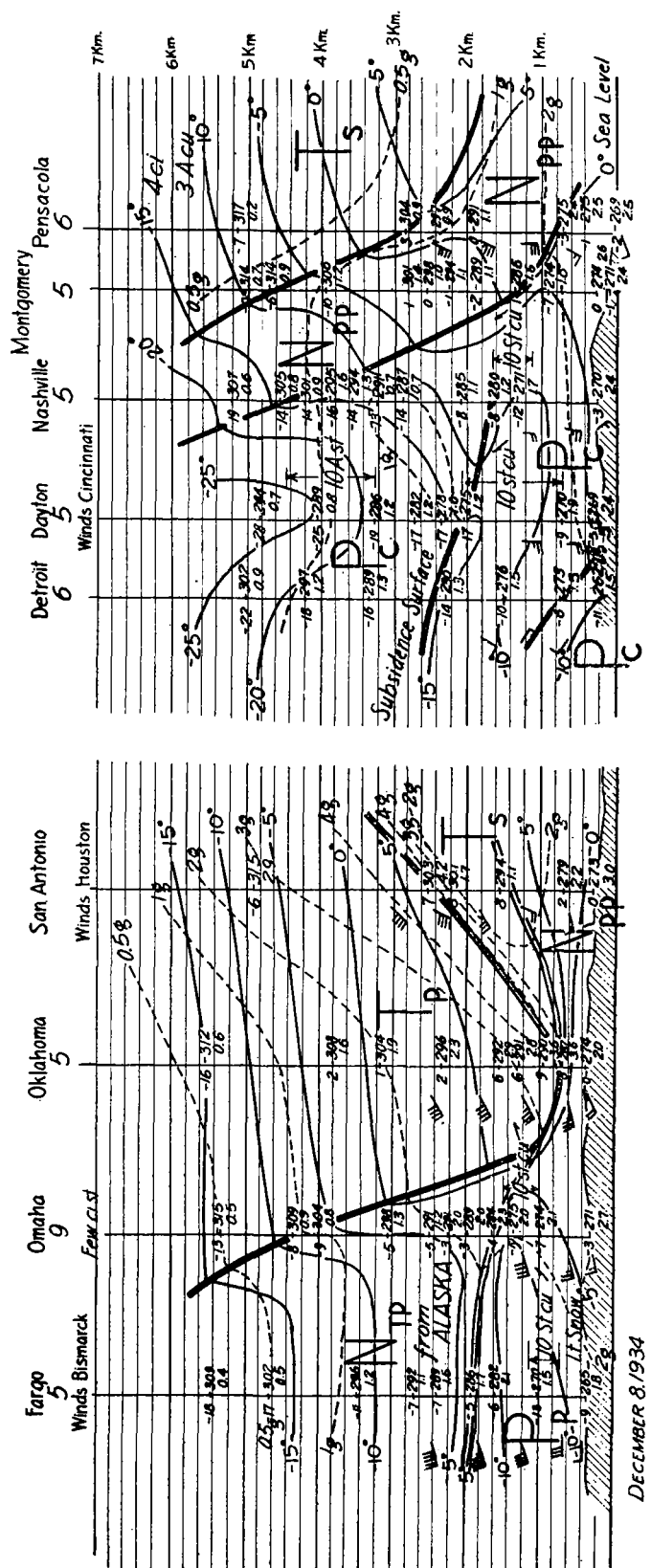
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tion of the fronts and air masses is completed, isopleths of specific humidity and of either temperature or potential temperature are drawn. This completes the cross-sectional representation.

The time required in the preparation of such a cross-section is not very great after one has had some experience. By an experienced man the determination of the specific humidities and the potential temperatures, the plotting of all the data, and the complete analysis of the major west-east section can be completed in less than 1½ hours. The smaller north-south sections can be completed in about ¾ hour each. The completion of the three cross sections, when the airplane reports are received from all stations, furnishes one with a rather complete and comprehensive picture of the state of the atmosphere, or the distribution and structure of the air masses and fronts, through the lower 5 km over most of the United States. The usefulness of this cross section in weather forecasting must be obvious to anyone familiar with weather maps. However, the purpose of this paper is only to explain the method of procedure, and not to discuss the results of this work. Extended experience is necessary before such a discussion of results can be satisfactory.

Besides the trouble caused by the frequent delay in the reception of the airplane sounding reports, another unfortunate feature of observations of this kind is that

they are likely to be missing at just the crucial points. Where meteorological action is at a maximum, weather conditions are likely to be such that no flight is made. Consequently on just those days, and in just those regions, where a good cross section would be especially instructive, we are likely to have nothing at all. Since the total number of stations represented on a cross section is very small, the absence of only one or two reports may result in a serious gap in the analysis; and in this type of analysis, just as in that of the surface map, continuity in the analysis from one day to the next is of fundamental importance. This constitutes one serious drawback to the usefulness of the method. It seems as though it should be possible eventually to overcome the present frequent delay in the transmission of the observations; but airplane soundings probably never will be made to an adequate elevation with perfect regularity. However, it is noticeable at the present time that the regularity of the flights, not only at the Army and Navy stations, but also at the Weather Bureau stations, falls far below the high standard set in previous years by such stations as those of the Weather Bureau at Dallas and Omaha. Probably the final solution of this difficulty will be found in the development of cheap and efficient radio-sounding instruments. This improvement would effect not only much greater regularity, but also much greater altitude.

METEOROLOGY AND CLIMATOLOGY IN A TEACHERS COLLEGE

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The chief purpose of this discussion is to present a brief survey of meteorology as it is taught today in colleges for the preparation of teachers. The material used in this paper has its principal sources in the writer's association with the curriculum building of the course used in the State of Pennsylvania, and in several years of experience in presenting the subject to the students of the State Teachers College at California, Pa. The data used for surveys outside the State of Pennsylvania are credited to W. C. Jacobs of the University of Southern California, who has made a careful survey of instruction in meteorology in the various colleges and universities of the United States.

In the preparation of a course for use in the teachers colleges, the author should attempt to give the student an insight into the physical processes and laws underlying the many different phenomena of weather and climate. The course should be designed primarily to lay a foundation for a more or less detailed study of climate and its relation to man. Since meteorology is admittedly a physical science it would seem most logical for it to be offered in the science departments along with physics and chemistry. In the survey made by Jacobs, it was found that in 46 percent of the cases meteorology was placed in the geography departments; 17 percent in the department of geography and geology; and only 8 percent in the department of physics. In only four colleges was meteorology allotted a department of its own. In the teachers colleges of Pennsylvania no such course has been delegated to the science departments, but it has been placed in the departments where courses in geography are offered.

Since 1930 meteorology has been included in our curriculum under the title of meteorology and climatology. In most teachers colleges, meteorology finds a place as a correlated subject with geography. In Penn-

sylvania it has been offered as an introduction to the study of the climates of the world, because the basic or fundamental principles set forth in meteorology serve well as an introduction to a systematic study of climatology. In offering the combined course of meteorology and climatology it has been found reasonably satisfactory to introduce the meteorological part with the physics and chemistry of the air. By this is meant the physical characteristics of the air and its chemical composition, and their variations. No attempt should be made to introduce the technical phases of the subject. Enough should be presented to challenge thought and to give a clearer and better approach to the study of climate.

Many students who elect this course have not had training adequate to pursue the more technical discussions of meteorology. In many instances the writer has known students who did not take a course in meteorology because they felt they had not had sufficient prerequisites for the work. That might be one of the reasons why so few have seriously considered courses in the field of meteorology. In a survey of 737 students enrolled in a teachers college it was found that all had had a course in general science during their high-school training. Of these, 262 had had at least 1 course in physics; and 487, or over one-half, a course in chemistry. It is interesting to notice the relatively small percentage who had a course in physics. It is not uncommon to hear a student who has the opportunity to pursue a course in meteorology say, "I can't take that, for I have not had enough work in physics and chemistry."

In the teachers college of Pennsylvania a course in meteorology and climatology is offered as a free elective for any student or as an elective for students who elect geography as one of their majors. In the survey made by Jacobs it was found that of the 252 courses offered, over one-half could be placed in the two major groups